WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2005WA119B

Title: Oxygenation for the Management of Sediment Mercury Release from Aquatic Sediments

Project Type: Research

Focus Categories: Water Quality, Surface Water, Sediments

Keywords: lakes, hypolimnetic anoxia, sediment, mercury cycling, methylmercury

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Congressional District: Washington, fifth

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Abstract

Problem Statement. Mercury (Hg) contamination in aquatic ecosystems is a growing concern throughout the US, including Washington. Hg is transported by atmospheric processes, so that aquatic systems far from direct sources may have elevated levels. Unlike many contaminants, Hg accumulates in upper-trophic-level organisms, thereby posing a health risk to people who consume contaminated wildlife. Recent surveys have shown elevated levels of Hg in aquatic sediments in an alarming numbers of lakes and streams. In Washington, several large lakes currently have advisories to limit fish consumption due to Hg contamination (Lake Roosevelt, Lake Washington, Lake Whatcom). Methylmercury (MeHg), the form that accumulates in biota, is produced via methylation of inorganic Hg by microorganisms, predominately sulfate reducing bacteria (SRB). Since SRB thrive under anaerobic conditions, methylation rates are higher under low-oxygen conditions. Studies have shown that hypolimnetic anoxia is a key pathway for exposure of biota to MeHg in lakes. Anoxic bottom waters accumulate MeHg during stratification, and fall mixing episodes inject MeHg into aquatic food webs. The number of lakes with anoxia problems is increasing as a result of cultural eutrophication, and Hg

levels in lake biota can be expected to increase concurrently. A clearer understanding of the environmental pathways for entry of MeHg into food webs is critical to understanding and controlling exposure of wildlife and humans to Hg. Lake oxygenation, already used by lake managers to control sediment nutrient release, may provide an efficient and cost-effective method to sequester Hg in aquatic sediments.

Research Objectives. Our principal objective is to test the efficacy of dissolved oxygen (DO) levels at the sediment-water interface in reducing the production and release of MeHg. We hypothesize that MeHg release is inversely related to the degree of oxygen penetration into the sediment profile. Increased oxygen levels at the sediment-water interface will lower MeHg release by: 1) inhibiting the activity of SRB, 2) acting as a diffusional barrier to MeHg produced in deeper layers, and 3) promoting the oxidative demethylation of upwardly diffusing MeHg by heterotrophic bacteria. Because Hg is already widely distributed in the environment, in-lake management strategies will need to be coupled with watershed and source control efforts for successful prevention of MeHg contamination in aquatic biota and subsequent threats to human health. This research will provide resource managers with an assessment of the potential for lake oxygenation, a widely used in-lake management strategy for nutrient control, to also reduce Hg contamination. It will provide guidance on quantification of oxygen requirements and on design criteria for oxygenation systems.

Research Methods. Undisturbed profundal sediment samples will be collected in bench-scale chambers at three sites representing a gradient in Hg pollution. Chambers are approximately 2 L in volume and have a surface area of 75 cm2. Replicate bench-scale chambers will be incubated over a range of DO, controlled by bubbling with gas that contains varying percentages of O2 and N2. Chamber water will be monitored for DO, redox potential, Hg, MeHg, nutrients, metals and sulfide. Sediments at each field site will be measured for a number of pertinent parameters including Hg, MeHg, organic content, total phosphorus and total nitrogen. Field monitoring will also be performed at one of the proposed study sites, Newman Lake, Washington. The field effort will evaluate hypolimnetic Hg distribution in bottom waters relative to sediment oxygen levels, and it will be coupled with ongoing studies by WSU researchers at the lake.